Seismic Analysis And Design Of Base Isolated Steel Buildings.

Suyog S. Thorat[1], Trupti Narkhede[2]

[1]PG student, Dept of civil engineering, Mahatma Gandhi Mission's College of Engineering and Technology (MGMCET), Kamothe, Navi Mumbai, Maharashtra, India.

[2]Professor, Dept of civil engineering, Mahatma Gandhi Mission's College of Engineering and Technology(MGMCET), Kamothe, Navi Mumbai, Maharashtra, India.

Abstract - *Industrial buildings often house critical infrastructure, heavy machinery, and sensitive equipment, making their seismic resilience paramount to preventing immense economic and structural losses. Traditional fixed-base designs dissipate seismic energy through structural damage, which can risk operational continuity. Base isolation techniques offer an effective alternative by decoupling the superstructure from ground motion. This paper presents an initial review and the framework for a comprehensive comparative study focused on the seismic analysis and design of a G+10 industrial steel building. The study evaluates and compares three distinct structural configurations: a conventional Fixed-Base system, a Lead Rubber Bearing (LRB) isolated system, and a High Damping Rubber Bearing (HDRB) isolated system. To assess their performance under varying seismic intensities, all three configurations are modeled and analyzed across Seismic Zones III, IV, and V using state-of-the-art structural analysis software (ETABS) in accordance with relevant Indian Standard (IS) codes. The primary objectives are to evaluate critical response parameters including fundamental time period, base shear, lateral displacement, and inter-story drift. This review synthesizes existing literature on Elastomeric Base Isolation systems applied to high-rise industrial frameworks, establishing the methodology for the upcoming parametric investigation. The ultimate outcome of this research aims to quantify the seismic vulnerability reduction offered by LRB and HDRB systems compared to fixed bases, providing optimal, zone-specific design recommendations for industrial steel structures.*

Key Words: [Base Isolation, LRB, HDRB, Industrial Steel Building, Seismic Zone, Vibration Control Methods, Comparative Study.]

I. INTRODUCTION

Industrial buildings are critical structures that house expensive machinery and sensitive equipment. Traditional fixed-base buildings transfer all seismic forces directly to the structure, which can cause heavy structural damage and operational shutdown during an earthquake. To avoid this, base isolation technology is used to separate the building from the ground, drastically reducing the earthquake forces acting on it.

This project focuses on a comparative study of a

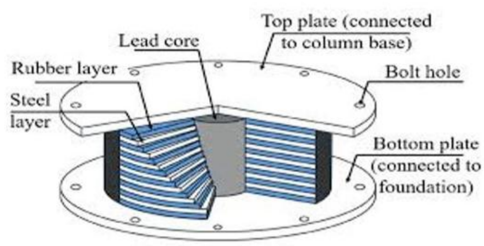

Fig.1 Lead Rubber Bearing Isolator

Fig.2 High Damping Rubber Bearing Isolator

industrial building using two popular isolation systems: Lead Rubber Bearings (LRB) and High Damping Rubber Bearings (HDRB).The performance of these systems will be evaluated against a conventional Fixed-Base structure. To understand their behavior under different earthquake intensities, the analysis is carried out across three seismic zones: Zone III, Zone IV, and Zone V using ETABS software as per IS 1893:2016 standards. The main goal is to compare key parameters like base shear, displacement, and time period to find the most efficient system for each zone.

II. LITERATURE SURVEY

- **Sreeman, Dasari (2025)** is focused on the performance of FPS and SMA-FPS isolated building under seismic excitations. Most analysis are carried out on the performance of FPS and SMA-FPS (Shape memory alloy=Friction Pendulum System) isolated structures. The results show that the SMA-FPS system outperforms the FPS isolation system in reducing isolator displacements and enhancing energy dissipation under strong ground motion. Future research is suggested to explore alternative types of isolators.

- **Chikmath, Channabasaveshwar (2025)** has primary purpose of this work is to describe and illustrate a direct displacement-based design procedure for RC buildings with and without seismic isolation using the Indian code spectrum. As the number of storey increases the ratio of base shear for base-isolated to fixed-base building increases. The method can be extended to plan irregular structures, building with setbacks

- **Gudainiyan et al. (2024)** has aim to verify the criteria of the "target time period" of the isolation bearing in a base isolated building as per IS 1893: 2022 (part 6). It was found that storey displacement increased with the time period but the rate of increase of storey displacement is observed to be decreased. The present study considered three models; square, C shape, and L shape models subjected to near-field ground motions. For base isolation, this study has used HDRB. Implementation of base-isolation technology in the building in hilly areas is missing.

- **Nawaz, Mohammad (2025)** presents a detailed investigation into the seismic performance of masonry buildings equipped with Unreinforced Elastomeric Isolators (UEI). The study was divided into three key phases: numerical analysis of masonry buildings with UEI, experimental investigations of masonry buildings with UEI

- **A.Jammi (2022)** done this study to understand the effect of non-structural wall panels on the nonlinear response of CFS buildings. The peak base shear increases linearly with an increase in NAR(non-structural area ratio).

- **Gudainiyan, Jitendra (2024)** has objective to study the response of irregular buildings with and without base isolation. They created the non-isolated variants of these models using the finite-element-based software SAP2000. For all the models, the storey displacement in base-isolated variants was found to be increased for most of the selected GMs. They also found that, depending on the ground motion, base isolation can significantly reduce or increase the torsional irregularity ratio. It was discovered that the building's fundamental time period had increased from 0.88 seconds to 2.6 seconds

- **Venkat (2025)** done Study on Optimum Location of Outrigger for High Rise Building. Study on optimization of high-rise building with Steel Plate Shear Walls using response spectrum analysis. Structural optimization of SPSW with different perforation configurations.Seismic performance of PSPSWs with various perforation patternsunder cyclic push over loading it is observed from the responses, there is no particular trend observed for a specific perforation geometry and pattern for all the heights. It is following a non -uniform response patterns. Type- (5D) shows lesser monitor displacements in all storeys when compared to other types due to rigidity at the peripheral boundary of the plate, there is chance of tearing of the plate takes place at edges of openings due to lateral displacements in the structure.

- **Motoki et al. (2024)** studied and reported the results of a full-scale shake table testing base-isolated hospital building using spherical sliding bearings and the associated prediction by a simple method and numerical simulation used in design practice. The paper also discussed simulation methods with good prediction accuracy and the preferable performance of base isolation devices for reducing hospital disorders.

- **Sapountzakisa (2024)** investigates the performance of K Damper-based devices (K Damper, 672 EKD,ENKD) when employed as supplementary components for seismic protection 673 at the base of a BI building equipped with conventional bearings .This study investigates the frequency-domain optimization of base isolated multistory buildings equipped with novel negative stiffness (NS) vibration control systems (VCS).

- **Adnan (2025)** studied and represents analytical investigation of a benchmark Japanese 9-story Sosokan building. The variation of the seismic response was investigated in case of the building has both a base isolation (BI) system and viscous dampers (BI&VDs) with different damping coefficients. To evaluate the effect of different LRB stiffness and viscous damper coefficients on the seismic response of the building, each building model was subjected to the Tohoku earthquake.

- **Saiful et al. (2018)** studied and reveals that the lateral force, displacement, inertia and floor acceleration of the seismic prone buildings are significantly reduced due to incorporation of lead rubber bearing. The nonlinear dynamic analysis shows 12 to 40% decrease in base shear due to LRB insertion ensuring momentous horizontal shift of the superstructure at the base and inertia reduction

- **Hongzhou, Yang (2018)** studied the probability of failure for two prototype buildings, each with different LRB geometric properties and axial loads, was systematically examined. State-of-the-art LRB buckling model implemented in OpenSees was used to check the probability of failure of the prototype buildings under a range of earthquake shaking intensities.

- **N Karimi (2025)** research has demonstrated the effectiveness of base isolation, particularly with Lead Rubber Bearings(LRBs), in improving the seismic performance of multi-story buildings. Overall, the implementation of base isolation enhances seismic resilience by reducing drift, shear, and acceleration demands, while improving energy dissipation and period elongation. To evaluate the seismic behavior of a G+12 Special Moment Resisting Frame (SMRF) reinforced concrete (RC) building, a detailed finite element model was developed using ETABS 2022 in accordance with IS 800:2007 and IS 456:2000.

II. SUMMARY OF LITERATURE REVIEW

Reviewing the research papers mentioned above, the following summary of the literature will be useful for my further work:

1. 1.Previous studies confirm that base isolation is an effective seismic protection technique that significantly reduces earthquake forces transmitted to the structure
2. Base isolated buildings show a considerable increase in fundamental time period compared to fixed base structures, leading to lower seismic demand.
3. 3.Comparative studies indicate a substantial reduction in base shear in base isolated structures as compared to conventional fixed base buildings.

II. GAPS IN LITERATURE REVIEW

1. Most existing studies focus on residential or high-rise buildings, while detailed seismic studies on industrial buildings are comparatively limited
2.Many studies analyze base isolated buildings but do not provide a direct comparison between fixed base and base isolated industrial structures.
3. Insufficient attention is given to the seismic response of steel industrial buildings with base isolation systems.

REFERENCES

1) Sreeman, Dasari.(2025)"Performance evaluation of FPS and SMA-FPS isolated buildings under seismic excitations," M.Tech Thesis, Dept. of Civil Engineering.

2) Chikmath, Channabasaveshwar. (2025) "Seismic Fragility Analysis of LRB Base Isolated RC Building Frames using Direct Displacement Based Design Subjected to Near and Far Field Earthquakes," International Journal of Structural Engineering.

3) J Gudainiyan, P K Gupta, N Gupta (2024) "Effect of Time Period Variation of HDRB on the Response of a Base-Isolated Building Under Near Field Earthquake." M.Tech Thesis.

4) Nawaz, Sheik Mohammed Zoheb (2025)" Evaluation of affordable unreinforced elastomeric isolators for seismic protection of masonry buildings Experimental and numerical investigations," Master's Thesis.

5) Ashok Jammi (2022)"Seismic performance assessment of cold formed steel buildings using shear wall panels with reinforced sheathing."Journal of Constructional Steel Research.

6) Gudainiyan, Jitendra (2024)."Seismic analysis of irregular buildings with and without isolation bearings."International Journal of Earthquake Engineering.

7) Venkat Rao Badugu (2025). "Structural Optimization of High Rise Steel Buildings."Journal of Structural Engineering.

8) Motoki Akazawa, Masahiro Kurata, Shinsuke Yamazaki, Yohsuke Kawamata, Shintaro Matsuo (2025)."Full-scale shake table testing of a base-isolated hospital building using spherical sliding bearings." Earthquake Engineering and StructuralDynamics.

9) Sapountzakisa (2024). "Performance evaluation of K Damper-based vibration control devices in base-isolated multistory buildings."Engineering Structures.

10) Adnan, Ahmed.(2025)."Seismic response investigation of buildings with Base isolation and viscous dampers."Soil Dynamics and Earthquake Engineering.

11) Saiful (2018). "Seismic response reduction of buildings using lead rubberbearings."International Journal of Civil Engineering Structtures

12) Hongzhou Zhang, TY Yang (2018). "Seismic safety assessment of base-Isolated buildings using lead-rubber bearings." Engineering Structures.

13) N Karimi, R Sarem.(2025)." Seismic response of multi-storey building using different vibration technique-A review."Journal of Building Engineering.

14) XiaoyueWang, Z Qu (2024)." Dynamic reliability-based assessment for the seismic performance of

semi-actively base-isolated buildings with hydraulic dampers."Structural Safety.

15) Abhishek patil, Adarsh solanke, Kuldeep Dabhekar, Isha Khedikar (2025)."Comparative seismic analysis of structures with and without seismic load."IOP Conference Series:Materials Science and Engineering.

16) N Cui, S Liu.(2024)." Seismic performance analysis of braced steel structures based on vibration experiments and finite element simulation."Journal of Constructional Steel Research.

17) Bharathi, K.M. (2023). "Experimental and numerical investigation on structural behaviour of steel winding columns." Doctoral thesis.

18) Podar,P.A.(2022)."Performance evaluation of cold-formed and hot-rolled composite beams." M.Tech Thesis.

19) Patil,A.N.(2024)."Parametric study on long-span steel gable frames subjected to vertical ground motion." Doctoral Thesis, DY Patil University, Pune.

20) Payal,Gwalani.(2023)."Seismic performance assessment of irregular RC buildings."M.Tech Thesis.

21) Varun,J.P.(2024)."Static, dynamic and aeroelastic analysis of smart composite laminated plates under hygro-thermal effects." Doctoral Thesis

22) Dawood M. (2025). Active vibration control of cantilever beam structures using piezoelectricsensor–actuatorpairs:Aparametricstudy."JournalofIntelligentMaterial Systems and Structures.